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Hierarchy and Opportunism in Teams*

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Abstract: We use experiments to compare two institutions for allocating the proceeds of team production. Under revenue-sharing, each team member receives an equal share of team output; under leader-determined shares, a team leader has the power to implement her own allocation. Both arrangements are vulnerable to opportunistic incentives: under revenue-sharing team members have an incentive to free-ride, while under leader-determined shares leaders have an incentive to seize team output. We find that most leaders forego the temptation to appropriate team output and manage to curtail free-riding. As a result, compared to revenue-sharing, the presence of a team leader results in a significant improvement in team performance.

JEL codes: C9, D2, H4, J3, L2
Keywords: team production, leadership, opportunism, experiments

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INTRODUCTION

Activities in group settings are prone to free rider problems when the actions of individual group members are not subject to enforceable contracts. Team production, public good provision, collective action, and common pool resource extraction, are well-known guises of the same basic problem. One classic solution by which groups may try to attenuate the free-rider problem is to install some kind of hierarchy within the group, for example, by appointing a "leader". By giving the leader a stake in the total benefits produced by the group (for example, a residual claimant status) she will have an incentive to reduce free riding, and by giving her the right to determine rewards to other group members she will also have the means to do so (Alchian and Demsetz, 1972).

A hierarchy, though, can have its own disadvantages. When the leader is a residual claimant she will be tempted to reduce the rewards to the other group members as this will increase the residual that accrues to her. This has been referred to as the central dilemma in a hierarchy: "how to constrain the self-interest of those with a stake in the inevitable residual generated by an efficient incentive scheme" (Miller, 1992, p. 155). As long as the actions of individual team members are non-contractable (i.e., not verifiable by a court of law), it will be impossible for a leader to commit to a scheme for rewarding team members. Therefore, the willingness of the leader to enforce a particular rule is subject to incentive problems, just as, in the absence of a leader, the willingness of group members to behave in accordance with the common interest is subject to incentive problems (Bianco and Bates, 1990; Binmore, 1998; Calvert, 1995).[1]

[1] Think of an employer who has an incentive to withhold wages even if employees work hard, or a policeman who has an incentive to fine citizens even if they obey the law.

In this paper we present an experiment designed to examine whether installing a leader can curtail free riding and improve welfare in groups. To do this we consider a team production setting under two institutional arrangements. In our revenue-sharing institution there is no leader, and each team member receives an equal share of team output. In our leader-determined shares institution a leader can monitor the effort of team members, and has discretion to allocate the proceeds from team production. Here, the leader can condition the allocation on the observed effort levels of the individual members, including her own, even though she cannot commit to a certain allocation. In other words, individual efforts are perfectly and costlessly observable, but not contractable.[2] Thus, the key feature of the leader-determined shares treatment is the leader's discretionary reward power.[3]

In our environment, standard theory, based on the assumption that individuals maximize own-earnings, predicts teams will perform just as inefficiently under revenue-sharing and leader-determined sharing. In the former case this is caused by the classic free-rider problem, while in the latter case this is because all team members will anticipate that the leader will appropriate all team output.

Our experimental results show that free-riding incentives indeed undermine performance in revenue-sharing teams. These results are qualitatively similar to those found

[2] This assumption accords well, for example, with the situation in some academic departments. In these, many heads will assert that they know which faculty members contribute more to the performance of the department, while at the same time they will find it impossible to write complete contracts to reward faculty on the basis of these contributions.

[3] Even though in practice contractual factors may limit the discretion of a leader, in many organizations she has substantial power to reward team members. This may include an ability to allocate simple pecuniary rewards, such as bonuses, but also the allocation of fringe benefits and task assignments, influence on career progression, as well as less immediate or tangible rewards. The essence of the dilemma we study is unchanged under the more moderate assumption that the leader has discretion to allocate *some* (rather than *all*) of the revenues that accrue to the group.

in previous experiments on the voluntary provision of public goods (see Ledyard, 1995, for a survey). In contrast, in the teams with leaders we find that most leaders forego the temptation to appropriate all of the team output for themselves, and manage to induce high team effort by giving nothing to shirkers and rewarding workers with an equal share of team output. Thus, we find that the presence of a leader results in a significant and substantial improvement in team performance.

Our experiment adds to the experimental literature that examines the force of institutional remedies to free riding. These include investigations of pre-play communication (Isaac and Walker, 1988; Ostrom, Walker and Gardner, 1992; Frey and Bohnet, 1996; Bochet, Page and Putterman, in press), group incentive contracts (Nalbantian and Schotter, 1997; van Dijk, Sonnemans, and van Winden, 2001), mutual monitoring (Ostrom, Walker and Gardner, 1992; Fehr and Gächter, 2000; Bowles, Carpenter, and Gintis, 2001, Sefton, Shupp, and Walker, 2002), and leading-by-example (Moxnes and van der Heijden 2003; Meidinger and Villeval, 2002, Potters, Sefton and Vesterlund, 2004; Gächter and Renner, 2004). To our knowledge, the only experimental paper examining central monitoring is Vyrastekova and van Soest (2003). They study a common pool resource extraction game in which a 'police officer' can try to collect fines from resource users who over-extract. The police officer can keep the fines for himself and is thus incentivised to monitor the users (just like a residual claimant). They find that the presence of the police officer curtails over-extraction substantially. An important feature of their environment is that the police officer cannot fine users who do not over-extract. Thus, in their experiment there is no possibility that police officers abuse their power. Central to the present paper is that leaders are free to implement *any* allocation of team output, thus their ability to discourage free riding relies crucially on their willingness to forgo the opportunity to appropriate all the team output for themselves.

A SIMPLE MODEL OF TEAM PRODUCTION

Our experiment is based on the following simple model of team production. Each team consists of 4 members and each member chooses either to contribute to team production ("work") or not ("shirk"). Let $e_i = 1$ if member i works and $e_i = 0$ if i shirks. Each team member has an endowment of 120 which he loses in case he decides to contribute. This can be interpreted as the disutility of work or as the return from some alternative activity. We suppose that team output is determined by the convex team production function $Q = 60\,(\sum e_i)^2$. That is, we assume that efforts of individual team-members are complementary: an individual's marginal product increases with the efforts of others.[4] Team output is then shared among team members so that i's payoff is

$$\pi_i = q_i + 120(1-e_i),$$

where q_i is the share of team output given to individual i, $0 \le q_i \le Q$, and $\sum q_i = Q$.

Consider first what efficiency entails. Total social surplus, as measured by aggregate payoffs, is

$$\sum \pi_i = 60\,(\sum e_i)^2 + 120 \sum (1-e_i).$$

Since this function is convex, either all must work or all must shirk for efficiency to be attained. If all team members work aggregate payoffs are 960, while if all shirk aggregate payoffs are 480. Thus, it is efficient for all team members to work.

[4] Alchian and Demsetz (1972) take this as a defining feature of team production.

Equilibrium under revenue-sharing

How will output be allocated in the absence of a leader? A natural benchmark to consider is that team output is divided equally, that is, $q_i = Q/4$. Under this revenue-sharing rule a team member's payoff is

$$\pi_i = 15\,(\sum e_i)^2 + 120(1- e_i).$$

Standard game theory supposes that each team member maximizes her payoff, taking as given the other team members' choices. Suppose that the rest of the team shirk. Then obviously the remaining team member should also shirk. Thus there is an inefficient equilibrium where all team members shirk. The only other candidate for an equilibrium is where all team members work. If the rest of the team work, the remaining team member earns 240 when working and 255 when shirking. This implies that shirking is a dominant strategy under revenue sharing and complete free-riding is the unique equilibrium.

In this revenue-sharing environment contributing to team production is analogous to contributing to a public good. Numerous experiments have shown that many individuals are willing to contribute to a public good, even when it is not in their narrowly defined self-interest to do so (Ledyard, 1995). However, often such cooperation is of a conditional nature (Fishbacher et al., 2001). Individuals are willing to contribute if others do so as well, but are not willing to contribute when others free ride. The typical pattern is for contributions to start somewhere halfway between the individually rational level and the collectively efficient level. Contributions then gradually decline with repetition as more and more conditional cooperators stop tolerating the presence of ever more free-riders. We see no reason to expect a different pattern for our revenue-sharing environment.

Equilibrium under leader-determined sharing

Suppose now that a leader has the authority to divide up the team output in any way she sees fit. Thus, the game consists of two stages. In the first stage team members (including the leader) simultaneously decide whether to work or shirk, and in the second stage the leader determines how team output will be divided up, where the leader can condition the division on the decisions observed in the first stage.[5]

Again, standard theory is easy to apply to this situation. A selfish leader will take any output for herself in the second stage, giving nothing to other team members. Anticipating this, the other team members should not work, as it is costly to do so and they expect to get no benefit. Since other team members do not work, the leader can either shirk and get a payoff of 120, or work and get at most a payoff of 60. Hence, the leader is better off shirking as well. In the unique subgame-perfect equilibrium each team members shirks and team output is zero.[6]

Repeated Game Considerations

In real-life settings as well as in our experiment teams interact repeatedly. Are there reasons to expect that cooperation will be easier to sustain in the presence of a leader? In our experiment the game will be repeated only a finite number of periods. Strictly speaking there

[5] In the terminology of Bianco and Bates (1990), our leader has “enhanced capabilities” rather than “limited capabilities” since not just total output, but also individual efforts, are observable.

[6] Since individual efforts are not contractable the leader cannot commit to rewarding team members conditional on their efforts. If team output is contractable, in principle the leader could write a forcing contract in which she promises to reward each team member with 120 (plus some small amount) if output is equal to 960 and to give them nothing if output is below 960. For such a contract only output needs to be verifiable. It is easily checked, however, that with such a contract the leader would have an incentive to free ride and make sure that the maximum output level is not reached, so that she need not pay the other team members (Holmstrom, 1982). So, the best output level a contract would be able to achieve is 540. We do not consider such explicit contracts in the sequel, however.

is no room for cooperation: in the unique subgame perfect equilibrium all team members shirk in every period for both environments. However, many experimental studies have found that players often manage to cooperate even in finitely repeated games with a unique stage game equilibrium (see, e.g., Engle-Warnick and Slonim, 2000, Selten and Stoecker, 1986).

A frequently used measure to examine the scope for cooperation is based on the use of *trigger strategies,* as introduced by Friedman (1971). The measure is the maximum discount rate, $\bar{r}$, that allows trigger strategies to support cooperation as a subgame perfect equilibrium in the infinitely repeated game:

$$\bar{r} = \frac{\pi^C - \pi^N}{\pi^D - \pi^C}$$

where π^N is the stage game payoff in the non-cooperative equilibrium, π^C is the stage game payoff from cooperation, and π^D is the stage game payoff from the best reply to cooperation (i.e., optimal defection).

Under revenue-sharing, we have $\pi^N = 120$, $\pi^C = 240$, and $\pi^D = 255$, implying a threshold discount rate of $\bar{r} = 8$. Under leader-determined shares the analysis is a bit more involved. First we have to determine the leader's sharing strategy. A selfish leader will try to induce the other members to work and at the same time keep as much of team output for herself as she can. The leader should give the others members at least 120 to keep them working. This implies that in the cooperative outcome the leader gets $\pi^C = 600$ (i.e., 960 – 3×120) and the other team members get $\pi^C = 120$. So, for the other team members there is no gain from cooperation. There is also no gain from defecting since the leader will not give them a share in team output if they shirk. So, for the other team members we have $\pi^N = \pi^C = \pi^D = 120$, implying that their discount rate does not matter. If the leader decides to defect, the best thing she can do is still to work, just like the others, and then to take all the team output for herself: $\pi^D = 960$. Since the leader gets $\pi^N = 120$ in the non-cooperative equilibrium, we find that the threshold discount rate for the leader is: $\bar{r}$ = 1.33.[7] This threshold is smaller than that in case of revenue-sharing, implying a more strict condition. So, from this perspective we should expect cooperation to be *more difficult* to sustain with a leader than without a leader. The reason is that defecting from the cooperative outcome is a very tempting option for the leader, and much more attractive than "plain" free riding under revenue-sharing.

There is a counter-balancing force, though. With revenue-sharing, the discount rate of *all* members has to be below the threshold discount factor for cooperation to be sustainable. The support of all team members is essential. With leader-determined shares, only the leader's discount rate matters. She should be (very) patient, but the discount rate of the other team members does not matter.

In summary, the introduction of a leader is predicted to be of little help in improving team performance. Under either revenue-sharing or leader-determined shares, standard theory predicts that all team-members will shirk. Even in a repeated game setting, installing a leader is not predicted to have an unambiguously positive effect. Sustaining cooperation relies on the pivotal role of the leader. The leader must be very patient and willing to forego large immediate private gains.

EXPERIMENTAL DESIGN

The experiment was conducted in Spring 2004 using subjects recruited by e-mail from a pool of undergraduate students at xxx. Five sessions were run, and 80 subjects participated in total, with no subject participating in more than one session.

[7] Note that this threshold becomes even smaller if the leader would give more than 120 to the other team members in case they work.

All sessions were computerized and used an identical protocol. Upon arrival, subjects were randomly assigned to a group of four subjects and randomly assigned an identification number: subject 1, 2, 3 or 4; these groups and identification numbers were kept fixed throughout the session. Subjects were then given a written set of instructions that the experimenter read aloud.[8] Subjects were allowed to ask questions by raising their hands and speaking to the experimenter in private. Subjects were not allowed to communicate with one another throughout the session, except via the decisions they entered on their terminal.

The decision-making phase of the session consisted of 15 rounds. At the beginning of each round the four subjects in each group were prompted to choose between two actions: A or B. The subjects made these choices simultaneously, and each choice of B increased group output as described in Table 1.

Table 1. Team Production Function

Number of group members choosing option B	0	1	2	3	4
Group Output	0	60	240	540	960

Subjects' earnings were determined as their share of group output, plus an additional 120 points if they chose option A. At the end of each round, subjects were informed of all group-members' choices and earnings. Thus, in terms of the model presented in Section 2, choosing A corresponds to shirking ($e_i = 0$), choosing B corresponds to working ($e_i = 1$).

[8] Reading the instructions aloud caused the information and move structure to become public knowledge. A copy of the instructions for the experiment can be found in Appendix A.

We employed two experimental treatments. In our revenue-sharing treatment, each subject received an equal share of their group's output irrespective of their own decision. In our leader-determined shares treatment subject 1 was informed of the decision of each group member, and then decided how to allocate the group output among the group members. Subjects were informed that subject 1 could "choose any division he or she wishes as long as no subject receives a negative share and the shares of the four subjects add up to group output." Both treatments were run with 10 different groups of 4 subjects each.

At the end of the experiment subjects were privately paid 0.4 eurocents per point, based on their accumulated point earnings from all 15 rounds. Sessions lasted between 40 and 70 minutes, and subjects earned on average 10.75 Euro (with a minimum of 4.75 Euro and a maximum of 18 Euro).[9]

RESULTS

Treatment Effects

We first present the results from treatment comparisons. Table 2 presents averages and standard deviations of team effort, team production, and team earnings for each treatment. For each group we averaged over all fifteen rounds, and then report the average and standard deviations of the resulting two sets of ten observations. We also report p-values for tests of treatment effects in the last row. [10]

[9] At the time of the experiment the exchange rate was approximately Euro 1 = $1.21.

[10] Throughout the paper statistics and tests are based on independent group level data.

Table 2. Treatment Comparisons

	Average Team Effort	Average Team Output	Average Team Earnings
Revenue-Sharing	1.75	314.0	583.6
	(1.08)	(276.9)	(151.2)
Leader-determined Shares	3.03	682.0	798.0
	(1.10)	(301.3)	(169.9)
p-value	0.038	0.034	0.031

Notes: p-values are based on Wilcoxon ranksum tests using the group-level data reported in Appendix B.

Relative to the revenue-sharing treatment, introducing a leader to allocate team output results in significant increases in average team effort ($p = 0.038$), output ($p = 0.034$), and earnings ($p = 0.031$). Under revenue-sharing, on average 1.75 team members work each round producing 314 units of output, while under leader-determined shares 3.03 team members work producing 682 units of output. Thus, these results clearly show that teams in which the leaders determine the shares work harder and produce more output than teams in which the shares are equally distributed. Because team earnings are not monotonically increasing in the amount of effort, it is not immediate that higher effort supply translates into changes in earnings.[11] However, as the last column shows, the presence of a leader also enhances team performance from a welfare perspective: introducing a leader results in a significant increase in team earnings from 583.6 to 798.0 ($p = 0.031$).

[11] With complete free-riding team earnings are 480, whereas a single effort decision lowers team earnings to 420. For the team to earn more than in equilibrium, either 3 or 4 team members must supply effort.

Standard theory predicts that teams will attain 50% of maximum attainable earnings in both treatments. In fact we find that on average teams attain 61% of maximum possible earnings in our revenue-sharing treatment. Thus, on average, team performance is a little better than predicted by standard theory, but still falls far short of efficient levels. In fact, three of ten teams earned less on average than the equilibrium level of 480 points per round, and the hypothesis that a team is equally likely to earn more or less than equilibrium predicts cannot be rejected ($p = 0.344$, using a two-sided Binomial test). In contrast, in teams where the leader determines how team output is allocated, all ten teams earned more than predicted by equilibrium, and average earnings are 83% of the maximum possible.

In each treatment 150 stage games were played, each resulting in team earnings of either 420 (if one team member worked), 480 (if none or two members worked), 660 (if three members worked), or 960 (if all worked) points. Table 3 gives the percentages of games resulting in each outcome. While in the revenue-sharing treatment most games resulted in payoffs at or below the equilibrium level, in the leader-determined shares treatment most games resulted in the efficient outcome. We next look for the sources of these differences by examining choices in each treatment separately.

Table 3. Stage Game Outcomes.

	Percentage of rounds in which team earnings equal			
	420	480	660	960
Revenue-Sharing	24	43	14	19
Leader-determined Shares	5	21	11	63

Effort and Earnings under Revenue-Sharing

Figure 1 shows how average team effort levels, aggregated over all ten groups of our revenue-sharing treatment and ten groups of the leader-determined shares treatment, developed across rounds.

--- Figure 1 here ---

We will focus first on the revenue-sharing treatment. In the first round 30 of 40 subjects chose to work. Four groups attained the efficient outcome, so that in these groups each team member earned 240 points. The other six groups included shirkers, and these shirkers earned 120 points more than fellow team members who chose to work.

Effort declined over subsequent rounds: after round seven, most subjects were shirking, and in the last round of the session all but four subjects shirked. This pattern is similar to the pattern of declining voluntary contributions observed in public goods experiments. As shown in Figure 2, this pattern of declining effort induces a similarly declining pattern in team earnings.

--- Figure 2 here ---

The averages shown in Figures 1 and 2 mask substantial variation across groups. To see this consider Figure 3, which shows how effort supply develops in each individual team. The four teams that attained efficient levels of production in round one also attained efficient production in round two (and two of these teams, labelled Equal_3 and Equal_4, managed to sustain efficient production levels for most of the experiment). In contrast, in five of the six teams where a team member shirked in round one, production fell in round two.

--- Figure 3 here ---

Although there appear to be several attempts to renew cooperation in these teams, the general trend of declining production and earnings is evident. Recall that in order for a team to earn more than equilibrium earnings, at least three team members must work. Across all ten teams, this occurred in 56% of cases in the first five rounds, 34% in the second five, and only 10% in the last five. Moreover, a similar pattern is observed in every team: the number of times the team attained greater than equilibrium earnings was at least as high in the first five rounds as the second five rounds, which in turn was at least as high as in the last five rounds. The general picture from our revenue-sharing treatment is that teams are unable to overcome the underlying free-riding incentives.

Effort and Earnings under Leader-Determined Shares

Turning now to our leader-determined shares treatment, Figure 1 shows that initial effort supply is high, remains high for most of the experiment, and then declines abruptly in the later rounds. Figure 2 shows that the same holds for average team earnings, which stay close to 840 until round 12.

Interestingly, it is not just the leaders but also the other team members who benefit from the presence of a leader. Leaders earn 238.8 points on average which is significantly more than the average earnings of 186.4 points of the other team members (two-sided Wilcoxon matched-pairs signed-ranks test $p = 0.016$). The latter earnings, however, are significantly higher than the average earnings (145.9) in the revenue-sharing treatments (two-sided Wilcoxon ranksum test $p = 0.089$). The reason for this is that leaders allocate a larger share of team output to the other working team members than what would be required (120) to compensate them for the cost of effort. On average, the leader allocates 187.3 points to another team member who chose to work (and only 3.2 points to another team member who chose to shirk). Notably, when all team members work, the average share that leaders allocate to another team member is 224.6 (i.e. 23.4% of team output). To see that the leader's behavior gives an incentive to other team members to work, consider what happened when three team members (including the leader) worked, and one team member shirked. In this situation, which occurred at least once in seven groups, the leader allocated herself 170 points, the other two workers 165 points each, and the shirker 26 points on average.

To fully appreciate the different strategies employed it is useful to discuss the behavior of some teams in detail. In the first round 35 of 40 subjects chose to work (including 9 of 10 leaders), and all ten teams earned more than the equilibrium level of earnings. How did leaders distribute team output? In seven of the ten teams, output was evenly divided among those team members who chose to work. That is, leaders allocated 180 points to a worker if output was 540, and allocated 240 points to a worker if output was 960. Shirkers were allocated zero, and so earned 120 points for the round. In all these teams output either remained the same or increased in the next round. In the other three teams the leader did not share output equally among workers, and team output fell in the next round.

Figure 4 shows how effort levels developed in each team over the rest of the experiment. The three teams where leaders did not divide first-round output equally among workers are shown in the first column; in the other columns are the seven teams whose leaders divided output equally among workers. To understand the further development of effort choices it is useful to consider these teams separately.

--- Figure 4 here ---

Consider the seven teams whose leaders divided output equally among workers in the first round and allocated nothing to shirkers. Five of these teams managed to keep earnings at the maximum, i.e. at 960, from round 2 until at least round 13. Another team attained 91% of maximum earnings until round 11 and the remaining team attained 76% of maximum earnings until round 14. Now consider the three teams in which output was not evenly divided among the workers. For two of these teams earnings were at or below equilibrium levels from round 3 onwards. Finally, in one of the three teams (labelled Leader_1 in Figure 4), the leader distributed output equally in round 2 (giving 60 points to all team members, including shirkers), and then in round 3 began using the strategy of dividing output equally among workers and allocating nothing to shirkers. So this leader seems to have eventually learned a successful strategy, since her team output stayed at efficient levels for most of the experiment.

The simple strategy whereby leaders divide output equally among workers, is employed by eight of ten leaders for most of the experiment.[12] Given this leader behavior, other team members have no incentive to free ride. As already seen in Figure 1, team effort levels remain high until near the end of the experiment, indicating that the leader is successful in encouraging team members to work. Figure 2 shows the earning implications: in contrast to the revenue-sharing treatment, earnings in the leader-determined shares treatment are substantially above the equilibrium level, though they decline somewhat toward the end of the session.

[12] One of these eighth leaders followed a somewhat more resentful and selfish strategy: when a subject chose to start working again after having shirked in the previous round, this leader ‘punished’ the subject by assigning less than an equal share (even in rounds thereafter). This happened to two subjects. The other team member did cooperate in all rounds, but the leader assigned less to this subject than to himself in rounds 7 and 8.

Discussion

What is the explanation for this effect of leadership? In a previous section we discussed how repeated game considerations might enable a team to perform efficiently. However, in that model a selfish leader allocates just enough to the other team members to induce them to work, while our leaders are typically more generous. On average our leaders allocate more than enough output to workers to compensate them for their effort, and indeed successful leaders typically give workers as much as they give themselves.[13] This might suggest that leaders have an intrinsic preference for "fair" distributions. A widely used model where payoffs refer to distributional considerations as well as to own-earnings is Fehr and Schmidt's (1999) model of inequality aversion. However, according to their model a sufficiently inequality averse leader is predicted to use her reward power to equalize earnings; instead, our leaders typically give very little to shirkers and equalize the earnings of the remaining team members.[14] Thus, if the allocations do reflect fairness considerations, our results suggest that leaders reward team members in accordance with their inputs, which is more in line with equity theory (Homans 1974).

Even so, closer scrutiny of endgame effects suggests that most of the apparently "fair" leaders may be only "acting fair" in earlier rounds. Of the eight leaders who encouraged team members to work by rewarding them, only two of these pursued this policy through to the end of the session. The other six "took the money and ran" in some round before the end of the session: one took 960 points in round 11, one took 960 points in round 13, three took 960 points in round 14, and one took 540 points in round 14. Having revealed their true colors, all

[13] The importance of ethical constraints on unbridled appropriation by leaders has been stressed since Barnard (1938).

[14] Furthermore, as we detail in Appendix C, inequality aversion does not unambiguously predict that teams with leader-determined shares will outperform those with revenue-sharing.

but three of the thirty subsequent decisions by other team members involved shirking. Of course, even if only two out of ten leaders seem intrinsically motivated by fairness consideration, the possible presence of these fair leaders may be enough to give other leaders an incentive to act fair in early rounds, in order to preserve a reputation that induces other team members to contribute (Kreps et al., 1982; see Brown et al., 2004, for an application in the context of incomplete contracting).[15]

CONCLUSION

Under revenue-sharing free-riding incentives are difficult to overcome in our experiment and the supply of effort decreases steadily with repetition. In contrast, in the leader-determined shares treatment free-riding incentives are effectively mitigated. Most team leaders use a simple strategy of dividing team output equally among workers and allocating nothing to shirkers. This strategy turns out to be very successful, and several teams attain a level of efficiency of 100% for a substantial period of time. The implication of this behavior is that team performance is significantly better with the introduction of a leader.

Installing a leader is no guarantee for success though. In our experiment, two out of ten teams with a leader perform poorly. Thus a critical factor is not just the availability of reward power, but how it is used. What characterizes these poorly-performing teams is that

[15] We note that Hollander's (1958) theory of idiosyncratic credits could be an alternative explanation for the fact that some leaders take more than an equal share of team output after having successfully managed the group for a substantial period of time. According to this (social psychological) theory credits are earned through the demonstration of competency in helping the group achieve goals and conforming to the group norms.

their leaders fail to send unambiguous signals of fairness. As a consequence, cooperation by the other team members breaks down.

While standard theory suggests that installing a hierarchy in order to overcome free-riding will merely shift opportunistic incentives, our results suggest that this prediction may be too pessimistic. We find that the presence of a team leader can be very effective. Obviously, the results in this paper are obtained using a very stylized set-up. Future research could study extensions and examine factors that influence the effectiveness of a hierarchy. First of all, the team leader in our experiment is well equipped. Individual actions are perfectly and costlessly observable. An obvious extension would be to examine the effectiveness of leadership in an environment with imperfect monitoring, for example, one in which individual effort levels are unobservable or only observable with noise. Second, due to the symmetric set-up of our experiment, it is quite obvious what a fair allocation of team output is. When the team members differ in their abilities or endowments there may be competing fairness standards (e.g., equity versus equality). It will be interesting to examine whether this erodes the constraining force of morality (e.g., due to self-serving biases), and how subjects react to that. A third extension would be to examine endogenous rather than exogenous leadership. If a team has the option to install a leader will they do so and if so how? Furthermore, will an endogenously selected leader be more effective or will she perhaps feel entitled to a larger share of the pie? It is likely that several of these alternative settings will make the effectiveness of a hierarchy more precarious. How it will compare to alternative arrangements in these settings is less clear *ex ante*.

APPENDIX A

The instructions given to participants are reproduced below. Text indicated by [] was only given to subjects in the leader-determined shares treatment, and text indicated by {} was only given to subjects in the revenue-sharing treatment.

Instructions

This session is part of an experiment in the economics of decision making. If you follow the instructions carefully and make good decisions, you can earn a considerable amount of money. At the end of the session you will be paid your earnings, in private and in cash.

It is important that you do not talk to any of the other participants until the session is over. If you have a question at any time raise your hand and a monitor will come to where you are sitting to answer it.

The session will consist of 15 rounds. During the session your earnings will be denoted in points. At the end of the experiment you will be paid an amount based on your total point earnings from all 15 rounds. Points will be converted to cash using an exchange rate of 1 point = 0.4 eurocents, which means 250 points = 1 euro.

Throughout the session you will be in a group with the same three other participants. The assignment of participants to groups is randomly determined by the computer at the beginning of the session. You will not be told who is in your group.

The four members of a group are labelled subject 1, subject 2, subject 3, and subject 4. Your subject number is randomly determined at the beginning of the session and will remain the same for all rounds.

Choices and earnings

In each round, each group member decides between option A and option B. If you choose option B this increases group output. Group output is determined by the following table.

Number of group members choosing option B	0	1	2	3	4
Group Output	0	60	240	540	960

As will be explained below, group output is divided among the group members. Your earnings for the round are: the share of group output you receive, plus an additional 120 points if you chose option A.

Stages and information

Every round has the same structure, and consists of a number of stages.

1. All group members decide between option A and option B.

[2. Subject 1 is informed of other group-members' decisions and group output.]

[3. Subject 1 decides how to divide group output among the four group members. Subject 1 can choose any division he or she wishes as long as no subject receives a negative share and the shares of the four subjects add up to group output.]

[4. All members of the group are informed of group output, and each group-member's decision, share of group output and earnings. If you want to retain this information for later rounds you can record it on the attached Record Sheet.]

{2. The group output is equally divided among the group members: each group member receives one-quarter (25%) of the group output.}

{3. All members of the group are informed of group output, and each group-member's decision, share of group output and earnings. If you want to retain this information for later rounds you can record it on the attached Record Sheet.}

Ending the Experiment

At the end of round 15 the experiment ends and each participant is paid his or her accumulated earnings, in private and in cash.

APPENDIX B

Table B-1 presents group-level data on average effort, output, and earnings under the two treatments. These underlie the statistical tests reported in the text.

Table B-1. Team Effort, Output, and Earnings

Group	team effort per round	team output per round	team earnings per round	Group	team effort per round	team output per round	team earnings per round
Equal_3	3.87	912	928	Leader_3	3.93	932	940
Equal_4	3.00	652	772	Leader_10	3.87	912	928
Equal_2	1.60	296	584	Leader_4	3.67	868	908
Equal_9	2.07	332	564	Leader_2	3.67	868	908
Equal_7	2.00	320	560	Leader_8	3.47	832	896
Equal_10	1.73	248	520	Leader_1	3.53	820	876
Equal_1	1.53	212	508	Leader_7	3.20	672	768
Equal_8	0.87	92	468	Leader_6	2.93	632	760
Equal_5	0.60	60	468	Leader_9	1.33	192	512
Equal_6	0.27	16	464	Leader_5	0.73	92	484
Average	1.75	314	584	Average	3.03	682	798

APPENDIX C

The Fehr-Schmidt model assumes that utility functions take the following form:

$$U_i = \pi_i - \frac{\alpha_i}{n-1}\sum_{j\neq i}\max\{0, \pi_j - \pi_i\} - \frac{\beta_i}{n-1}\sum_{j\neq i}\max\{0, \pi_i - \pi_j\},$$

where the parameter α_i reflects the individual's *inferiority aversion* and the parameter β_i reflects the individual's *superiority aversion*. Fehr and Schmidt assume that $0 \leq \beta_i < 1$, $\beta_i \leq \alpha_i$. For both revenue-sharing and leader-determined shares, the inefficient equilibrium identified in the main text, in which all team members shirk, remains an equilibrium for any values of these parameters. We derive conditions on the parameters that support additional efficient equilibria.

Revenue-sharing. If three other team members work, then by also working the remaining team member receives utility 240, whereas by shirking she receives utility $255 - 120\beta_i$. Thus, efficient outcomes can be supported as an equilibrium iff, $\beta_i \geq 1/8$ for all *i*. An efficient equilibrium requires all team members to be sufficiently superiority averse.

Leader-determined shares. There are two cases to consider for the leader's level of superiority aversion β_L:

i) $\beta_L < 3/4$. If all team members work, then the leader maximizes her utility by keeping all the output and the other team members would each receive a utility of $-320\alpha_i$. There is a unilateral incentive for one of the team members to shirk, since then they would get utility $120 - 140\alpha_i - 80\beta_i > 40 - 140\alpha_i > -320\alpha_i$. Thus there is no subgame perfect equilibrium where all team members work in this case.

ii) $\beta_L \geq 3/4$. In this case if team output is 540 or 960 the leader maximizes her utility by allocating team output to equalize earnings. If all team members work, this means that they will each earn 240 and get a utility of 240. There is no unilateral incentive to shirk since then the shirker would earn 165 and get a utility of 165. In this case there is a subgame perfect equilibrium where all team members work.

Thus, efficient outcomes can be supported as an equilibrium iff $\beta_L \geq 3/4$. An efficient equilibrium requires the leader to be sufficiently superiority averse.

Comparison. The critical degree of superiority aversion required to support an efficient equilibrium is higher in the leader-determined shares case. However, only the leader's parameter needs satisfy the condition, whereas in the revenue-sharing case the (weaker) condition has to hold for all team members. Thus, under leader-determined shares, sustaining cooperation relies on the pivotal role of the leader. The leader must be willing to forego large private gains, but if she is willing to do so he removes other team members' incentives to shirk.

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FIGURES

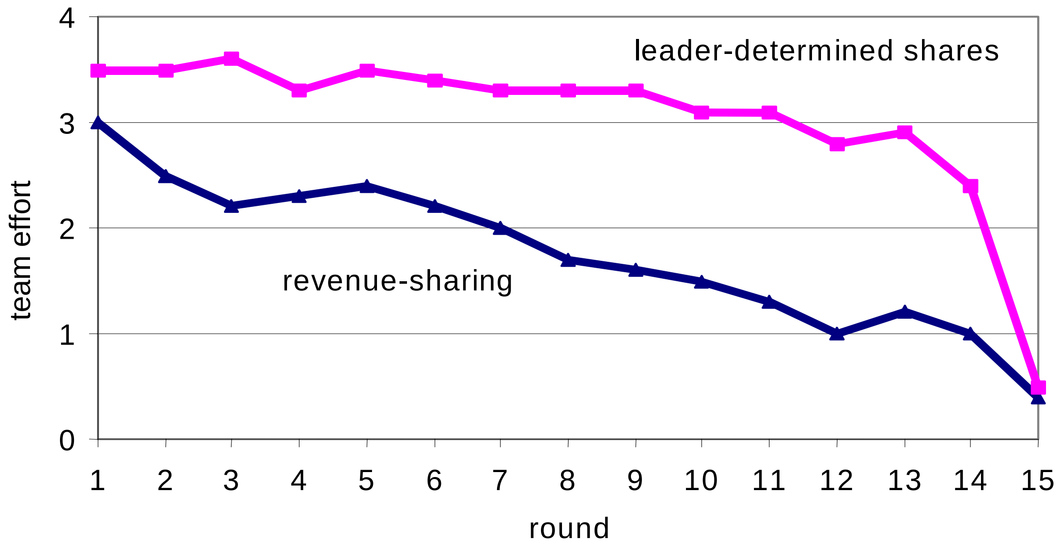

Figure 1. Average team effort levels

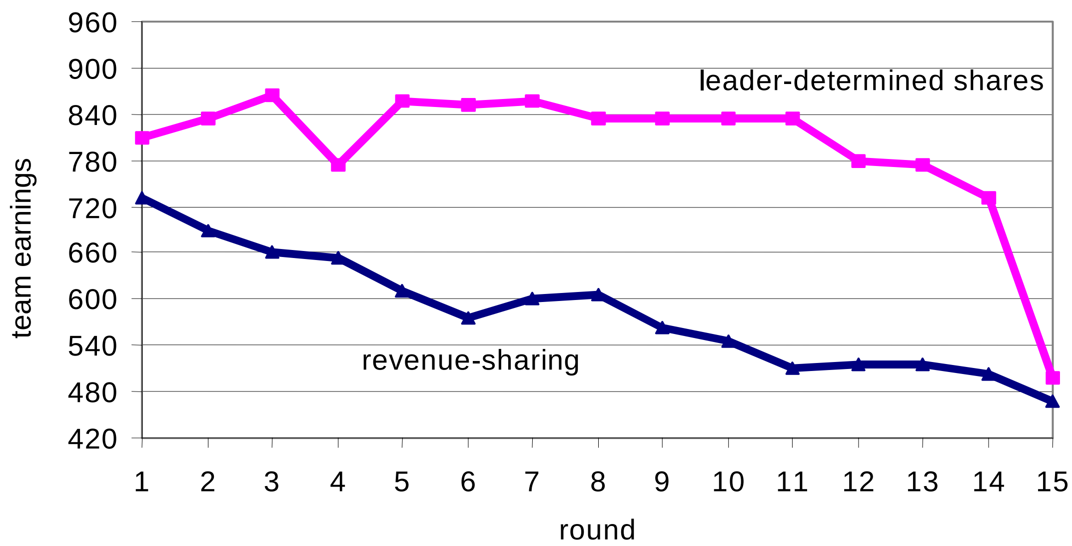

Figure 2. Average team earnings

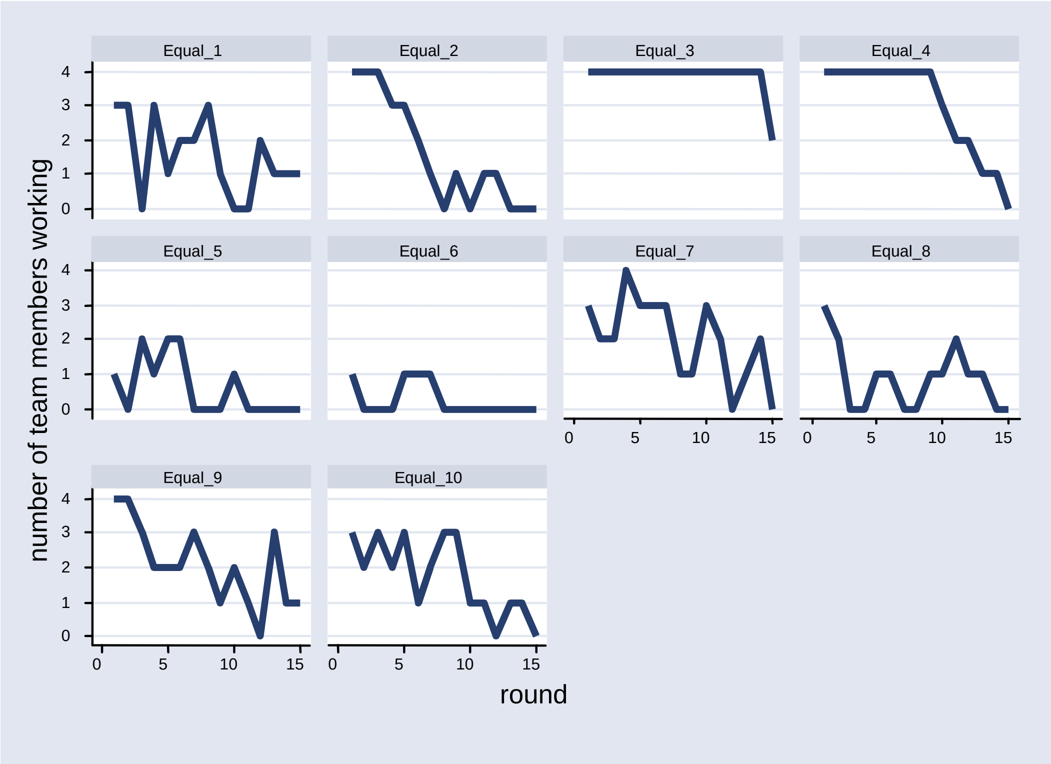

Figure 3. Team effort levels: revenue-sharing treatment

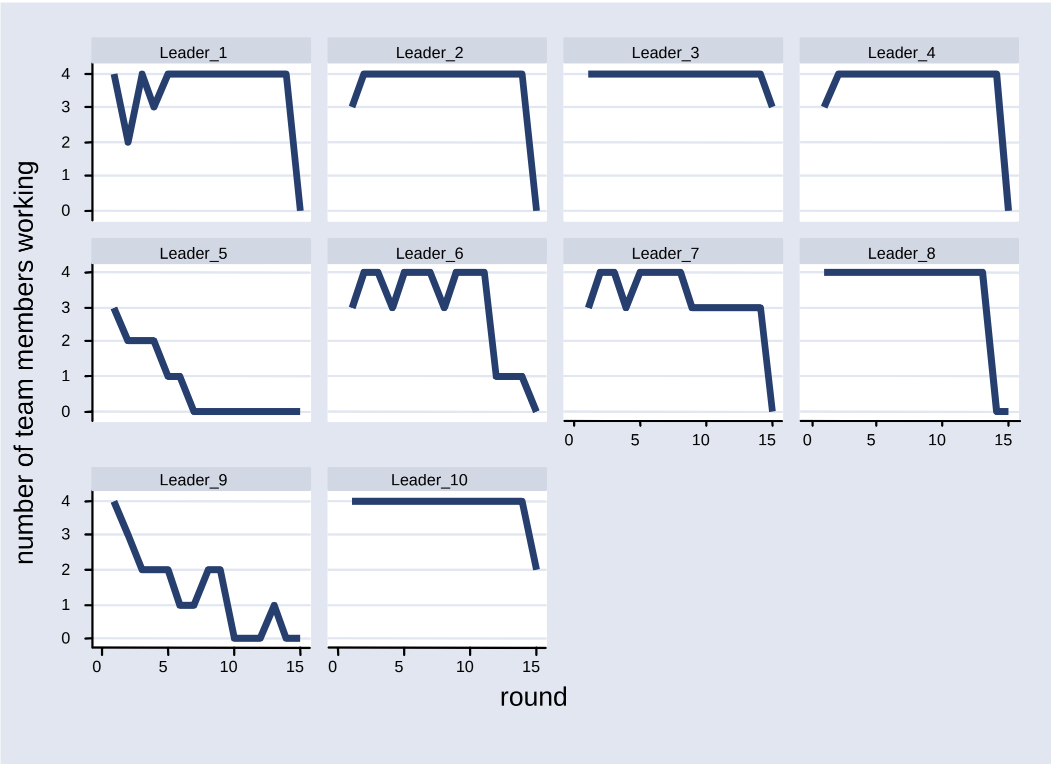

Figure 4. Team effort levels: leader-determined shares treatment